
# Automated driving in urban environments: technical challenges, open problems and barriers

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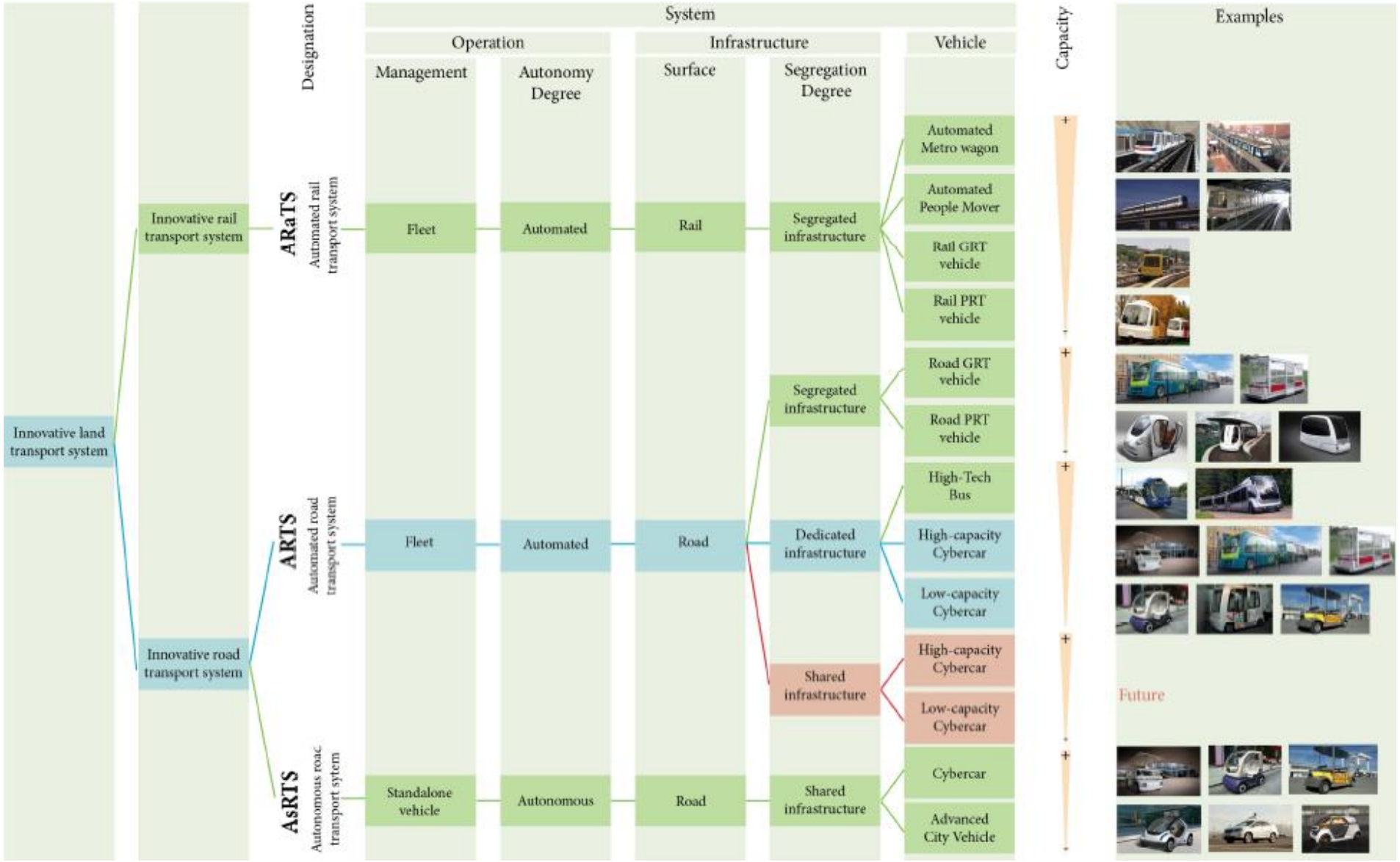
# What is automation ?

- For which use and which benefits ?
- For what type of vehicles ?
- For which environment ?
- To whom is it addressed ?
- What do we mean by vehicle automation ?


Innovative land transport system
Innovative rail transport system
Innovative road transport system
Designation
ARaTS
Automated rail transport system
ARTS
Automated road transport system
AsRTS
Autonomous road transport system
System
Operation
Management
Autonomy Degree
Infrastructure
Surface
Segregation Degree
Vehicle
Fleet
Automated
Rail
Segregated infrastructure
Automated Metro wagon
Automated People Mover
Rail GRT vehicle
Rail PRT vehicle
Fleet
Automated
Road
Segregated infrastructure
Road GRT vehicle
Road PRT vehicle
Dedicated infrastructure
High-Tech Bus
High-capacity Cybercar
Low-capacity Cybercar
Shared infrastructure
High-capacity Cybercar
Low-capacity Cybercar
Standalone vehicle
Autonomous
Road
Shared infrastructure
Cybercar
Advanced City Vehicle
Capacity
+
-
Examples
Future

# Technical & scientific challenges

**Today:**

Several demonstrators can navigation safely with own capacities

**However:**

**Still simple or « calibrated » in most cases**:

e.g. Keep lane, stop on obstacles, use of pre registered maps for navigation

Example of Leon showcase

**Need for a priori knowledge and assumptions:**

e.g.: roundabouts & intersections information

(radius, number of exits or branches, branches orientations…)

**Intelligent individual maneuvers and behaviors**

- What to do in case of a stopped obstacle ?
- Who takes the responsibility of overtaking ? Can AV take risks ?!
- Human supervision ? Cooprative maneuvers ?

**Cooperative maneuvers:**

Beyond GCDC and basic ACC functions !

⇨ Cooperative perception and maneuvers.

Penetration rate ?

Reliability / quality / quantity / safety of remote information ?

V2V vs V2I ⇨ Do we need instrumented infrastructure ?

**Amount of Intelligence on board vs in the infrastructure**

**Technology:**

Need for realistic sensors and architectures (costs)

**Methodology:**

Semantic navigation: using occlusion, classification, semantic closures, texture reasoning, etc.

**Arbitration and shared driving**

**Driver profiling**

**Fault tolerance/ redundancy**

# How to implement ?

- **How to implement ?**
  - Technical developments
  - Integration: technical and… redunduncy, fault tolerance, interoperability
  - Certification
  - Liability & Legal issus: authorization, maintenance, insurance…
  - Acceptance
  - Public authorities involvement ?
  - Dedicated or equipped Infrastructure ?
  - Economic benefits and business models
    - Penetration rate

# Challenges to widespread deployment of automated urban transit vehicles

1. **Lack of an established legal framework** for allocating risks and responsibilities

2. **Lack of directive** to define regulatory framework:
    1. leaving each country on its own to set up its own framework
    2. unmanageable complexity for system developers and suppliers dealing with inconsistent requirements

3. **Diversity of safety certification** approaches and requirements, with a general risk that this is likely to be a slow and expensive process

4. **Larger up-front capital costs than other alternatives**, without a convincing way of showing net life-cycle cost/benefit advantages

5. **Risk to system deployers and operators** that small company suppliers of new systems may not survive to provide needed product support for the full life of the product

# Challenges to widespread deployment of automated urban transit vehicles

6. Challenges **in physically retrofitting a new system** into an existing built environment

7. **Need for a well thought-out concept of operations** of how driverless vehicles should interact with pedestrians and other vehicles

8. **Need to overcome public anxieties** about seeing driverless vehicles moving in their vicinity

9. **Opposition by labor unions** fearing loss of bus driver jobs if driverless vehicles are used instead of conventional buses

10. **Limitations of system capabilities** restricting their application to low-density or fully controlled environments in order to provide acceptable safety

# Challenges to widespread deployment of automated urban transit vehicles

11. **Perceived to be high risk** alternatives by risk-averse public authorities
    - Public agencies perceive significant non-technical risks associated with automated vehicle deployment, in addition to the technical risks.
    - PRT systems : have uniquely designed vehicles that must operate on uniquely designed guideways, so that once a locality commits to deploying a specific system
    - vulnerable to monopoly pricing for future expansions,
12. **Operating costs:** existing relatively small fleet driverless vehicle operations have comparable operating costs to conventional bus systems !
    - Maintenance labor costs vs. lack of driver labor costs
13. **Safety:** Cybersecurity…

# On the other hand….

- **Public attitudes** in Europe were shifting in favor of innovative transit services
  - valuing mobility rather than car ownership
- **Marketing approaches** were suggested to make the transit options emotionally appealing to people
- **Dedicated e-Lanes ?**
  - A special subset of the roadway infrastructure in which the vehicle automation functions can be used
  - How much physical separation would be needed between the eLanes and other traffic ?
  - More research is needed to determine what levels of automation can be applied with what degrees of physical protection from intrusion
  - NAHSC researchers encountered in the U.S. in the 1990s: dedicated and protected lanes one of the most controversial issues.

✓ **Fully automated vehicles cannot be mixing entirely freely with conventional traffic unless they are operated at very low speeds.**

✓ **Some degree of separation and protection is needed**